HUMAN BIONICS

A Amanda Kitts is mobbed by four- and five-year-olds as she enters the classroom. "Hey, kids, how're my babies today?" she says, patting shoulders and ruffling[1] hair. Slender and energetic, she has operated this Knoxville, Tennessee, daycare center and two others for almost 20 years. She crouches down to talk to a small girl, putting her hands on her knees.

B "The robot arm!" several kids cry. "You remember this, huh?" says Kitts, holding out her left arm. As she turns her hand palm up, there is a soft whirring sound. If you weren't paying close attention, you'd miss it. She bends her elbow, accompanied by more whirring.

C "Make it do something silly!" one girl says. "Silly? Remember how I can shake your hand?" Kitts says, extending her arm and rotating her wrist. A boy reaches out, hesitantly, to touch her fingers. What he brushes against is flesh-colored plastic, fingers curved slightly inward. Underneath are three motors, a metal framework, and a network of sophisticated electronics. The assembly is topped by a white plastic cup midway up Kitts's biceps, encircling a stump[2] that is almost all that remains from the arm she lost in a car accident in 2006.

D Almost all, but not quite. Within her brain, below the level of consciousness, lies an intact image of that arm—a phantom. When Kitts thinks about flexing[3] her elbow, the phantom moves. Impulses racing down from her brain are picked up by electrode sensors in the white cup and converted into signals that turn motors, and the artificial elbow bends.

E "I don't really think about it. I just move it," says Kitts, who uses both this standard model and a more experimental arm with even more control. "After my accident, I felt lost. These days I'm just excited all the time, because they keep on improving the arm. One day I'll be able to feel things with it and clap my hands together in time to the songs my kids are singing."

F Kitts is one of "tomorrow's people," a group whose missing or ruined body parts are being replaced by devices **embedded** in their nervous systems that respond to commands from their brains. The machines they use are called neural prostheses or—using a term made popular by science fiction writers—bionics.

G The kind of prosthesis that Amanda Kitts uses is controlled by her brain. A technique called targeted muscle reinnervation uses nerves remaining after an amputation[4] to control an artificial limb. It was first tried in a patient in 2002. Four years later, Tommy Kitts, Amanda's husband, read about the research, which took place at the Rehabilitation Institute of Chicago (RIC). His wife lay in the hospital at the time; the truck that had crushed her car had also crushed her arm, from just above the elbow down.

H "I was angry, sad, depressed; I just couldn't accept it," she says. But the news Tommy brought her about the Chicago arm gave her some reassurance, and some hope. "It seemed like the best option out there, a lot better than motors and switches," Tommy says. "Amanda actually got excited about it." Soon they were on a plane to Illinois.

I Todd Kuiken, a **licensed** medical practitioner and biomedical engineer at RIC, was the person responsible for what the institute had begun calling the "bionic arm." He knew that nerves in an amputee's stump could still carry signals from the brain, and he knew that a computer in a prosthesis could direct electric motors to move the limb. However, making the connection was far from straightforward. Nerves conduct electricity, but they can't be spliced together with a computer cable. (*Nerve fibers and metal wires are not mutually* ***compatible***, and an open wound where a wire enters the body would be a dangerous avenue for infections.)

1 If you **ruffle** someone's hair, you lightly push it up.
2 A **stump** is the base portion of a body part that remains after the rest has been amputated.
3 When you **flex** something, usually a muscle, you bend it.
4 An **amputation** occurs when a body part is removed, usually for medical reasons.

J Kuiken needed an amplifier to boost the signals from the nerves, avoiding the need for a direct contact between nerve and wire. He found one in muscles. When muscles tense, they give off an electrical burst strong enough to be detected by an electrode placed on the skin. He developed a technique to reroute severed nerves from their old, damaged spots to other muscles that could give their signals the proper boost.

K In October 2006, Kitts consented to have Kuiken try out his new technique on her. The first step was to ***salvage*** major nerves that once went all the way down her arm. "These are the same nerves that work the arm and hand, but we had to create four different muscle areas to lead them to," Kuiken says. The nerves started in Kitts's brain—in the motor cortex, which holds a rough map of the body—but they terminated at the end of her stump. In an ***intricate*** operation, a surgeon rerouted those nerves to different regions of Kitts's upper-arm muscles. For months the nerves grew, millimeter by millimeter, moving deeper into their newly ***assigned*** homes.

BIONIC MAN

As scientists work to link machine and mind, artificial bones, organs, joints, and limbs (parts shaded green and blue) are gaining many of the capabilities of human ones.

① Images captured by a video camera in glasses are converted to signals and sent wirelessly to an implant in the eye. Electrodes in the eye send the signals to the optic nerve, which sends them to the brain, and a person is able to *"see"* the images.

② Implants stimulate nerves inside the ear, allowing people who are partially or completely deaf to hear.

③ Signals are sent from the brain to the bionic arm via electrodes attached to nerves in the injured arm. The result: a person is able to grasp and manipulate objects.

④ A bionic ankle copies the action of a real one by pushing the wearer forward, helping the person to walk again.

L "At three months, I started feeling little tingles and twitches," says Kitts, "and by four months, I could actually feel different parts of my hand when I touched my upper arm. I could touch it in different places and feel different fingers." What she was feeling were parts of the phantom arm that were mapped into her brain, now reconnected to flesh. When Kitts thought about moving those phantom fingers, her real upper-arm muscles contracted.

M A month later, she was fitted with her first bionic arm, which had electrodes in the cup around the stump to pick up the signals from the muscles. Now the challenge was to convert those signals into commands to adjust the elbow and hand. A storm of electrical noise was coming from the small region on Kitts's arm. Somewhere in there was the signal that meant "straighten the elbow" or "turn the wrist." A microprocessor inserted in the prosthesis had to be programmed to differentiate the right signal and send it to the right motor.

N Kitts practiced using her arm one floor below Kuiken's office in an apartment set up by occupational therapists. The apartment had a kitchen with a stove, silverware in a drawer, a bed, a closet with hangers, a bathroom, and stairs—things people use every day without a second thought but that pose huge obstacles to someone missing a limb.

O Watching Kitts make a peanut butter sandwich in the kitchen is a startling experience. With her sleeve rolled back to reveal the plastic cup, her motion is fluid. Her live arm holds a slice of bread, her artificial fingers close on a knife, the elbow flexes, and she swipes peanut butter back and forth. "It wasn't easy at first," she says. "I would try to move it, and it wouldn't always go where I wanted." But she worked at it, and the more she used the arm, the more lifelike the motions felt.

P What Kitts would really like now is **sensation**. That would be a big help in many actions, including one of her favorites—gulping coffee. "The problem with a paper coffee cup is that your hand will close until it gets a solid grip. But with a paper cup, you never get a solid grip," she says. "That happened at Starbucks once. It kept squeezing until the cup went *'pop.'"*

Q There are ***valid*** reasons for supposing that one day she'll get that sensation, says Kuiken. In partnership with bioengineers at the Johns Hopkins University Applied Physics Laboratory, RIC has been developing a new prototype[5] for Kitts and other patients that not only has more flexibility—more motors and joints—but also has pressure-sensing pads on the fingertips. The pads are connected to small rods that poke into Kitts's stump. The harder the pressure, the stronger the sensation in her phantom fingers.

R "I can feel how hard I'm grabbing," she says. She can also differentiate between rubbing something rough, like sandpaper, and smooth, like glass, by how fast the rods ***vibrate***. "I go up to Chicago to experiment with it, and I love it," she says. "I want them to give it to me already so I can take it home. But it's a lot more complicated than my take-home arm, so they don't have it completely reliable yet."

S Today, Kitts has a new, more elastic cup atop her arm that better aligns electrodes with nerves that control the arm. "It means I can do a lot more with the arm," she says. "A new one up in Chicago lets me do lots of different hand grasps—I want that. I want to pick up pennies and hammers and toys with my kids." These are reasonable hopes for a substitute body part, Kuiken says. "We are giving people tools, and they are better than what previously existed. But they are still **crude,** like a hammer, compared with the complexity of the human body."

T The work of neural prostheses is extremely delicate, a series of trials filled with many errors. As scientists have learned that it's possible to link machine and mind, they have also learned how difficult it is to maintain that bond. Still, bionics represents a major leap forward, enabling researchers to give people back much more of what they've lost than was ever possible before.

U "That's really what this work is about: restoration," says Joseph Pancrazio, program director for neural engineering at the National Institute of Neurological Disorders and Stroke. "When a person with a spinal cord injury can be in a wheelchair, feeding himself, and no one else notices, that is my definition of success."

5 *A **prototype** is an early model of a product that is tested so that the design can be changed if necessary.*

A. Choose the best answer for each question.

GIST

1. The best alternative title for this reading would be _____.
a. Bionics, the Next Generation of Prosthetics
b. The Latest Varieties of Robots
c. Amanda Kitts: A Brief Biography
d. A Short History of Prosthetic Limbs

VOCABULARY

2. In paragraph C, the phrase *brushes against* is closest in meaning to _____.
a. looks at carefully
b. touches briefly
c. grasps tightly
d. pushes away quickly

DETAIL

3. In paragraph F, who does *tomorrow's people* refer to?
a. doctors who treat people who have lost limbs
b. all people who have a missing or damaged body part
c. scientists who are developing advanced bionic limbs
d. people who have prosthetics controlled by their brains

DETAIL

4. According to the author, the term *bionics* _____.
a. is older than the term *neural prosthesis*

b. was popularized by science fiction authors
c. is no longer in regular use today
d. refers to the people who wear prostheses

DETAIL

5. In paragraph J, the *amplifier* proposed by Kuiken _____.
a. is an electric motor that is placed directly on the skin
b. sends signals from damaged nerves to the brain
c. is a muscle that helps link nerve signals to electrodes
d. receives a signal directly from a computer cable

REFERENCE

6. In the last sentence of paragraph M, the word *it* refers to _____.
a. the correct signal
b. the prosthesis
c. the right motor
d. a microprocessor

INFERENCE

7. In paragraph P, the author implies that the paper coffee cup went *'pop'* because Kitts _____.
a. did not know how hard she was squeezing the cup
b. could not feel how hot the coffee was
c. did not realize how full the cup was
d. could not tell that the cup was already empty

VOCABULARY PRACTICE

COMPLETION

A. Complete the information by circling the correct words.

The effectiveness of bionic technology is continuing to improve, helping thousands of people to regain abilities and ***sensations / salvages*** they had previously lost. For example, a(n) ***valid / intricate*** piece of equipment ***embedded / assigned*** in a patient's chest can help restore hand movement lost due to paralysis. Scientists also hope to develop new materials that will help make machine parts more ***compatible / licensed*** with the human body.

DEFINITIONS

B. Complete the sentences. Circle the correct options.

1. Something that is **crude** is *simple and basic / complex and refined*.
2. A **valid** argument or idea is based on *incorrect / sensible* reasoning.
3. If you manage to **salvage** a difficult situation, you make it *better / worse*.
4. Something that **vibrates** shakes with *small, quick / large, uneven* movements.
5. If something is **assigned** to someone, it is officially *given to / taken from* them.
6. A **licensed** individual has an official *qualification / request* to do something.

COLLOCATIONS

C. The nouns in the box below are often used with the adjective **valid**. Complete the sentences using the correct words.

concern – data – point – reason

1. Many people were unhappy with the tax increase. They could see no valid ______ for it.
2. The rising crime rate is a valid ______ for people in many parts of this country.
3. Before proposing their new theory, the scientists ensured they had obtained valid ______.
4. I thought the President made a valid ______ when she suggested that more needed to be done to help the country's poorest people.

BEFORE YOU WATCH- A GIANT STEP

A. The words in **bold** appear in the video. Match each word with its definition.

Cutting-edge bionic devices are giving **paralyzed** people the chance to walk again. The technology is still at an early stage, but trials on a number of patients have been hugely promising, with many participants noting the **overwhelming** sensation of standing upright for the first time in years. Today's devices are not yet able to provide a full-time replacement for wheelchairs—they are very slow, heavy, and difficult to turn. However, in addition to helping with injury **rehabilitation**, they also provide relief to **paraplegic** patients from the medical side-effects of being confined to a wheelchair for long periods.

1. **paraplegic** •   a. the treatment of physical disabilities
2. **paralyzed** •   b. someone who cannot move the lower half of their body
3. **rehabilitation** •   c. affecting someone very strongly
4. **overwhelming** •   d. being unable to move and having no feeling in a part of the body